Passive Catheter Tracking/Visualization using Frequency Demodulation and IDEAL

O. Unal[1], E. K. Brodsky[1], and S. B. Reeder[1]
[1]Medical Physics and Radiology, University of Wisconsin-Madison, Madison, WI, United States

INTRODUCTION

MR visible coatings that exploit T1-shortening effect of paramagnetic contrast agents such as Gd-DTPA have been shown to facilitate passive tracking and visualization of catheters and guidewires [1-2]. This passive method allows visualization of the entire length of a device independent of its orientation in the magnetic field. Another known but not widely exploited effect of MRI contrast agents is that they cause a shift in proton resonant frequency due to bulk magnetic susceptibility (BMS). This work investigates the effect of BMS frequency shifts in combination with MR visible coatings for evaluation of passive tracking and visualization of coated catheters.

IDEAL [3] is a multi-point chemical shift-based water-fat decomposition technique that provides uniform separation of fat and water in the presence of B0/B1 inhomogeneities. IDEAL has been successfully combined with the VIPR-ME sequence [4-5], a highly efficient multi-echo 3DPR technique, to reconstruct catheter-only or water/proton images from a single set of scan data.

MATERIALS AND METHODS

All experiments were performed on a 1.5 T cardiac scanner (GE Healthcare, Waukesha, WI) using the VIPR-ME sequence that acquires eight half-echoes on eight separate radial projection angles during each TR. Image volumes were acquired over a 32 cm diameter spherical FOV with an acquired matrix size of 256x256x256, and an isotropic spatial resolution of 1.25 mm using SPGR mode with a 10-30° flip angle. Catheters were filled with concentrations of Gd-DTPA ranging from 5 mM to 50 mM and imaged using the multi-echo sequence. To increase sensitivity to specific (Gd-DTPA) off-resonant spins, frequency demodulation was performed during reconstruction by multiplying the complex raw data by a complex phasor prior to regridding. The demodulation frequency was varied over a range of –400 to +400 Hz to determine the frequency shift induced by Gd-DTPA. In addition, the IDEAL decomposition technique was also applied to catheter images to isolate Gd-DTPA (catheter) only images from water/proton (background) images. These positive-contrast catheter-only images were color-coded and overlayed onto the background image.

RESULTS AND DISCUSSION

Figure 1 shows temporal snapshot coronal (left) and sagittal (right) images of a moving Gd-filled catheter obtained using the 3D PR technique in a phantom. All images were reconstructed using various techniques on a single acquired dataset. The roadmap images (top) were reconstructed without frequency demodulation and the catheter-only images (middle) were reconstructed with demodulation for a 350 Hz frequency shift. These images are then combined (bottom), with the catheter-only images colored in blue and superimposed onto the red-colored background (roadmap). Similarly, Figure 2 shows a coronal image of a Gd-filled catheter in a water filled phantom. The colored catheter-only image was reconstructed using the IDEAL technique and is shown superimposed on the background (roadmap) image from the same data. Note that both methods presented here obviate acquiring separate roadmap images. Since both the dynamic catheter-only and background (roadmap) images are obtained from the same data, image registration is not an issue unlike other techniques that use previously acquired roadmap images.

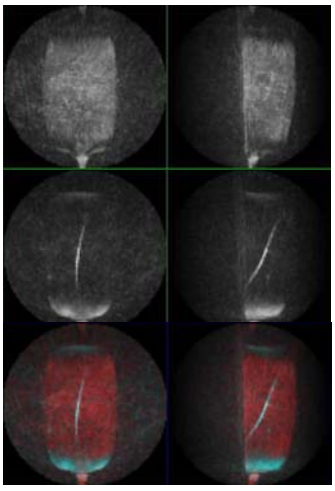

Figure 1: *Temporal snapshot coronal (left) and sagittal (right) images of a moving Gd-filled catheter in a phantom. Roadmap image (top) and catheter only image reconstructed with 350 Hz frequency shift (middle). Colored catheter only image is shown superimposed on the background roadmap image.*

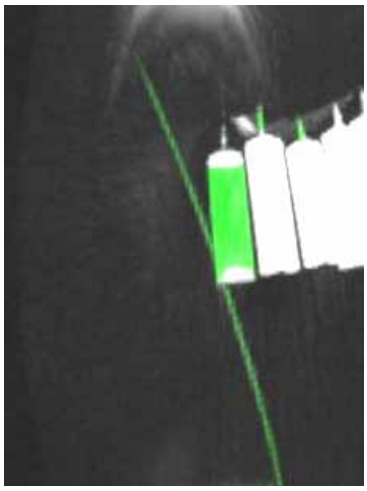

Figure 2: *Coronal image of a Gd-filled catheter in a water filled phantom. Colored catheter only image reconstructed using the IDEAL technique is shown superimposed on the background (roadmap) image.*

CONCLUSIONS

Our preliminary results demonstrate the potential utility of frequency shift-based passive device tracking and visualization of catheters filled with Gd-DTPA or coated with MR visible coatings. The reconstruction may use simple demodulation or the IDEAL technique to improve resistance to B0 inhomogeneity. This may be a powerful complementary and/or alternative technique to T1-based visualization of coated catheters.

REFERENCES

1. Unal, *et al.*, MRM, 40, 356, 1998.
2. Unal, *et al.*, JMRI, 23, 763, 2006.
3. Reeder, *et al.*, MRM, 51, 35, 2004.
4. Brodsky *et al.*, *Proc. Eleventh ISMRM*, 322, 2003.
5. Brodsky *et al.*, *Proc. Fourteenth ISMRM*, 629, 2006.

ACKNOWLEGMENTS

This work was supported in part by NIH grant 1R01CA116380-01A1.